two American Black Snakes (*Zamenis constrictor*), ten Pennsylvanian Mud Terrapins (*Cinosternum pennsylvanicum*), four Adorned Terrapins (*Chrysemys ornata*), thirteen Elegant Terrapins (*Chrysemys scripta elegans*), six Lesueur's Terrapins (*Malacoclemmys lesueuri*), six Red Newts (*Sperlepes ruber*) from North America, a Garnett's Galago (*Galago garnetti*) from East Africa, a Serval (*Felis serval*) from Africa, a Common Teguexin (*Tupinambis teguexin*), three Annulated Terrapins (*Nicoria annulata*) from South America, four Blue Wall Lizards (*Lacerta muralis*, var. *coerulea*) from Faraglione, five Schlagintweit's Frogs (*Rana cyanophlyctis*) from Southern Asia, deposited; a Barbary Wild Sheep (*Ovis tragelaphus*, ♂), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE DARK FRINGES OBSERVED DURING TOTAL SOLAR ECLIPSES.—We have received a communication from Señor V. Ventosa, astronomer at the Madrid Observatory, concerning the appearance and probable cause of the dark fringes—or "shadow bands" as they are generally called—which are always observed some few seconds before and after totality during the progress of a total eclipse of the sun. The chief points of his communication are here summarised.

These alternating dark and bright fringes are parallel to each other, all moving in the same direction, but the velocity varies greatly from time to time. Several reasons have been advanced to account for their appearance, chief of which are those regarding them as (1) diffraction fringes bordering the actual shadow of the moon on the earth's surface; (2) shadow phenomena produced in the body of our own atmosphere, and affected by the direction of the wind. The examination of the observed facts appears to support to some extent those holding the latter view, as while the bands may be well seen in one place, they may be invisible in a neighbouring locality; their form, generally rectilinear or slightly undulating, is also variable, while their breadth has been variously estimated from 1 cm. to 50 cm., although this will, of course, partly depend on the inclination of the surface on which they are observed. Sometimes they move with about the speed of a man walking, at others with the speed of an express train, the velocity always being less, however, than that of the shadow itself. (During the coming eclipse the shadow will move through 800 kilom. in 12 minutes.)

Señor Ventosa has been occupied for some time in studying the currents in the higher regions of our atmosphere by observing the undulations round the sun and stars with a telescope, and thinks that these upper atmospheric currents may possibly have some bearing on the question of the eclipse shadow bands; the movement of these higher portions showing through the quieter lower strata and being rendered visible on account of different refractive powers. He thinks it would be useful to determine the velocity of these currents by anemometers at various altitudes, and also to observe the undulations round the limb of the sun at the time of eclipse, comparing them with the shadow bands in direction and velocity of movement. To ascertain if any experimental illustration of this hypothesis could be presented, he states that bands may be produced by passing diffuse light reflected from a sheet of corrugated glass through a circular aperture representing the sun, over which an opaque disc, representing the moon, is made to slide. When the segment left uncovered is about 5 mm. in width, alternate bright and dark bands can be observed on a white screen held near, if the length of the segmental opening is approximately parallel to the undulations of the glass, but if at right angles they entirely disappear. He trusts, however, that his putting forward this hypothesis for establishing a connection between eclipse shadow bands and atmospheric undulations will show the advisability of recording the direction and velocity of the wind during eclipses, so that more definite data may be available for discussion.

PHOTOMETRY OF CORONA, APRIL 16, 1893.—In a communication recently made to the Royal Society, Prof. H. H. Turner, F.R.S., gives the details of procedure and results obtained in photometric observations of the corona during the total eclipse of the sun in April 1893. The visual brightness of the corona was determined by Prof. T. E. Thorpe at the eclipses of 1886 August 29, and 1893 April 16, by a method arranged by Sir W. Abney (*Phil. Trans.* A, 1889, p. 363, and 1896, p. 433), but soon after the first of these, Sir W. Abney devised a method of comparing the coronal light with that of a fixed standard by photographic means. This method was first put into practice at the eclipse of 1889, and has been repeated systematically since. Part of the photographic plate, before being taken for eclipse use, is exposed to a graduated series of exposures from a standard source of light in the laboratory, and then without development is afterwards used to receive the impression of the corona, the part carrying the previous standard exposures being protected from further light action. On subsequent development there results a picture of the corona, and a series of squares of graduated densities on the same plate, so that the brightness of any part of the coronal structure may be directly compared with the brightness of the standard light of the laboratory.

The 1889 photographs have not yet been measured, but Prof. Turner has reduced several of the plates taken in 1893 by Sergeant Kearney at Fundium, Africa. These were obtained with the "double tube" apparatus, giving pictures of two sizes, the moon's disc being 0·6 inch and 1·5 inches in diameter. Examples of each scale image were examined, one of the large scale photographs, taken with an exposure of 50 seconds, being specially carefully measured along four radii extending due N., S., E., W., from the limb respectively, and the resulting table of comparison measures is included in the present paper. This table shows:—

(1) That the accuracy of the method is such that the intensity of the light is determinable within a very small error.

(2) The intensity of the coronal light falls off in nearly the same manner in all four directions (1893 was near a sun-spot *maximum*, with corona of symmetrical form). There is a marked difference, however, between the intensities along the north and south radii.

(3) The falling off in intensity is at first exceedingly rapid, becoming very gradual at distances more than 45 minutes from the limb.

(4) The absolute brightness of the corona in terms of the "moon" by using a conversion factor.

Prof. Turner then compares the brightness thus determined photographically with that obtained visually by Abney and Thorpe, and presents two curves showing the combined observations, which show a marked agreement between the results arrived at in such different ways. No measures of brightness, however, were made *visually* within 0·6 of a radius from the limb, and it would be useful if this were done at the coming eclipse.

MAXIMUM DURATION OF TOTALITY FOR SOLAR ECLIPSE.—Mr. C. T. Whitmell sends us the following corrections to the data given in the abstract of his paper last week (p. 64):—

Earth's radius to be taken as 3963·296 miles.
Moon's ,, ,, ,, ,, ,, 1080·000 ,,

The eclipse for which the totality will be a maximum will take place at noon about the beginning, not the middle, of July.

SOME MODERN EXPLOSIVES.[1]

NEARLY thirty years ago, in the Royal Institution, I had the honour of describing the great advances which had then recently been made both in our knowledge of the phenomena which attend the decomposition of gunpowder, and in its practical application to the purposes of artillery.

I described the uncertainty which up to that date had existed as to the tension developed by its explosion, the estimates varying enormously from the 101,000 atmospheres (about 662 tons on the square inch) of Count Rumford to the 1000 atmospheres (6·6 tons per square inch) of Robins, or, taking more modern estimates, from the 24,000 atmospheres (158 tons per square inch) of Piobert and Cavalli to the 4300 atmospheres (about 29 tons per square inch) of Bunsen and Schischkoff.

These uncertainties were, I think I may say, set to rest by certain experiments carried out both in guns and close vessels at Elswick, by the labours of the Explosive Committee appointed

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[1] A Discourse delivered at the Royal Institution on Friday, March 23, by Sir Andrew Noble, K.C.B., F.R.S.

by the War Office, and by researches conducted by Sir F. Abel and myself. These researches were conducted on a large scale with the view of reproducing as nearly as possible in experiment the conditions that exist in the bore of a gun. You may judge of the magnitude of the experiments when I tell you that I have fired and completely retained in one of my cylinders a charge of no less than 28 lbs. of ordinary powder.

The result of the discussion of the whole series of experiments led to the following conclusions :—

(1) That the tension of the products of combustion at the moment of explosion when the powder practically filled the space in which it is fired—that is, when the density is about unity—is a little over 40 tons on the square inch, or about 6400 atmospheres.

(2) Although changes in the chemical composition of powder, and even changes in the mode of ignition, cause a very considerable change in the metamorphosis experienced in explosion, as evidenced by the proportions of the products, the quantity of heat generated, and the quantity of permanent gases produced, being materially altered, it is somewhat remarkable that the tension of the products in relation to the gravimetric density is not nearly so much affected as might be expected from the considerable alteration in the above factors.

(3) The work that gunpowder is capable of performing in expanding in the bore of a gun was determined both by actual measurement and by calculation, and the results were found to accord very closely.

(4) The total potential energy of exploded gunpowder supposed to be fired at the density of unity was found to be about 332,000 gramme units per gramme, or 486 foot tons per lb. of powder.

I must confess that when I gave the lecture I have referred to, seeing the many centuries during which gunpowder has held its own as practically the sole propelling agent for artillery purposes, seeing also that gunpowder differs in certain important points from the explosives to which I shall presently call your attention, I had serious doubts as to whether it would be possible so far to modify these latter as to permit of their being used in large charges and under the varied conditions required in the naval and military services.

Gunpowder is not like gun-cotton, cordite, nitro-glycerine, lyddite, and other similar explosives, a definite chemical combination in a state of unstable equilibrium, but is merely an intimate mixture of nitre, sulphur and charcoal, in proportions which can be varied to a very considerable extent without striking differences in results. These constituents do not, during the manufacture of the powder, suffer any chemical change, and being a mixture it cannot be said under any condition truly to detonate. It deflagrates or burns with great rapidity varying very largely with the pressure and other circumstances under which the explosion is taking place, a train like that to which I set fire taking as you see an appreciable time to burn ; while, in the bore of the gun, a similar length of charge would be consumed in less than the hundredth part of a second.

You will further have observed the heavy cloud of smoke which has attended the deflagration you have seen. Nearly six-tenths of the weight of the powder, after explosion, remains as a finely divided solid, giving rise to the so-called smoke familiar to many of you, and of which a good illustration is shown in this instantaneous photograph. By way of comparison I burn similar lengths of gun-cotton in the form (1) of cotton, (2) of strand, (3) of rope, and you will observe the different rates at which these varied forms of the same material are consumed, the rate depending in this case upon the greater aggregation and higher density, consequently higher pressure, of the successive samples.

Although the names of cordite and ballistite are probably familiar to all of you, the appearance may not be so familiar, and I have here on the table samples of the somewhat Protean forms which these explosives, or explosives of the same nature, are made to assume.

Here, for instance, are forms of cordite, the explosive of the service, for which we are indebted to the labours of Sir F. Abel and Prof. Dewar. This, which is in the form of fine threads, is used in small arms, and here are successive sizes, adapted to successive larger calibres, until we reach this size which is that employed for the charge of the 12-inch, 50 ton guns.

A couple of the smaller cords I burn, both for purposes of comparison and to draw your attention to the entire absence of smoke.

The smoke of the gunpowder you see still floating near the ceiling, but little or no trace of smoke can be seen from such explosives as gun-cotton, cordite or ballistite, their products of combustion being entirely gaseous.

You will have observed that in the combustion which you have just seen there is no smoke, but I must explain, and I shall shortly show you, that this combustion is not quite the same as that which takes place, for instance, in the chamber of a gun. Here the carbonic oxide and hydrogen, which are products of explosion, burn in the air, giving rise, with the aid of a little free carbon, to the bright flame you see, and somewhat increasing the rate of combustion. In a gun, however, owing chiefly to pressure, the cordite is consumed in a very small portion of a second.

In order to illustrate the effect of pressure upon the rate of combustion, I venture to show you a very beautiful experiment devised by Sir F. Abel. It has been shown in this room before, but it will bear repetition.

In this globe there is a length of cordite. I pass a current through the platinum wire on which it is resting and you see the cordite burns. I now exhaust the air and repeat the experiment. The wire is red-hot, but the cordite will not burn. That the failure to burn is not due to the absence of oxygen is shown by plunging lighted cordite into a jar of carbonic acid, where, although a match is instantly put out, the cordite continues to burn—but observe the difference. There is no longer any bright flame, although the cordite is being consumed at about the same rate as when burned in air ; and when a sufficient quantity of the CO_2 is displaced, I can make the inflammable gases ignite and burn at the mouth of the jar.

Another illustration is also instructive. I have here a stick of cordite wrapped round with filter paper ; I dip it in water and light the end ; you may note that at first you see the bright flame. But as the combustion retreats under the wet filter paper, there appears a space between the flame and the cordite, the flame finally disappears, hot gases with sparks of carbon alone showing.

One other pretty experiment I show. I have here a stick of cordite which I light—when fairly lighted I plunge it in this beaker of water. The experiment does not always succeed at the first attempt, but you now see the cordite burning under the water much as it did in the jar of carbonic acid. The red fumes you observe are due to the formation of nitric peroxide caused by the decomposition of the water by the heat.

I have on the table samples of certain other smokeless explosives of the same class. Here is a ballistite used in Italy. Here is some Norwegian ballistite. Here again is ballistite in the tubular form, and in these bottles it is seen in the form of cubes. Here is some gelatinised gun-cotton in the tubular form, and here are some interesting specimens with which I have experimented, and which up to a certain pressure gave good results, but which exhibited some tendency to violence when that pressure was exceeded. Here also are some samples of the French B.N. powder, consisting of nitro-cellulose partially gelatinised and mixed with tannin, and with barium and potassium nitrates. Lastly, I show you here a sample of picric acid, a substance which has been used for many years as a colouring material, but which will be of interest to you because it is used as the explosive of lyddite shell, concerning which I shall presently have more to say ; it differs from all the other explosives in being, in the crystalline form, exceedingly difficult to light. I fuse, however, in this porcelain crucible, a small quantity. I pour a little on a slab, and on dropping a fragment into a red-hot test-tube you see with how much violence the fragment explodes. I also burn a small quantity, and you will observe that, unlike gun-cotton, cordite and ballistite, it is not free from smoke, the smoke in this case being simply carbonaceous matter. You will observe also how much more slowly it burns.

The composition of these various explosives (although in the case of both cordite and ballistite I have experimented with samples differing widely in the proportion of their ingredients) may be thus stated.

The gun-cotton I employed was of Waltham Abbey manufacture, and, when dried, consisted of 4·4 per cent. of soluble cotton and 95·6 per cent. of insoluble; as used, it contained 2·25 per cent. of moisture.

The service cordite consists of 37 per cent. trinitro-cellulose, with a small proportion of soluble gun-cotton, 58 per cent. of nitro-glycerine and 5 per cent. of the hydrocarbon vaseline.

The ballistite I principally used was composed of 50 per cent. dinitro-cellulose (collodion cotton) and 50 per cent. of nitro-glycerine. The whole of the cellulose was soluble in ether alcohol, and the ballistite was coated with graphite.

The French B.N. powder consisted of nitro-cellulose partly gelatinised, and mixed with tannin, and with barium and potassium nitrates. The transformation experienced by some of these explosives is given in Table I., while the pressures in relation to the gravimetric densities of some of the more important are shown in Fig. 1.

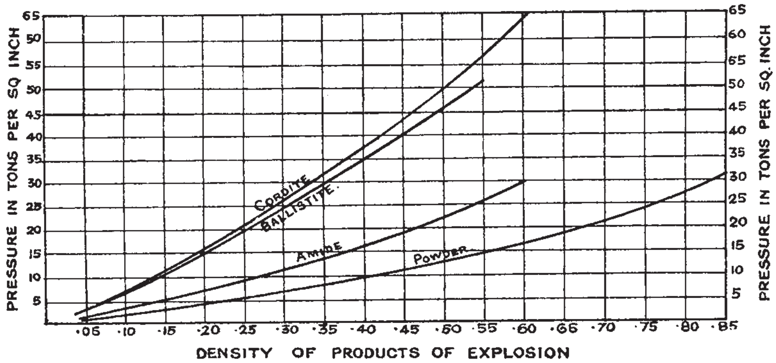

FIG. 1.—Pressures observed in closed vessels with various explosives.

TABLE I.

Constituents	Cordite	Ballistite	B.N.	Lyddite
	vols.	vols.	vols.	vols.
CO_2	20·5	29·1	21·1	12·8
CO	23·3	21·4	24·2	49·7
H	16·5	15·0	16·4	13·8
N	14·6	10·1	12·6	19·6
H_2O	23·6	24·4	25·0	3·8
CH_4	1·5	trace	0·6	0·3
Quantity of gas in c.c. per gramme ...	890·5	807	822	960·4
Units of heat ...	1272	1365	1003	856·3

The decomposition experienced by these high explosives on being fired is of much greater simplicity than that experienced by the old powders, and is, moreover, not subject to the considerable fluctuations in the ultimate products exhibited by them.

The products of explosion of gun-cotton, cordite, ballistite, &c., are at the temperature of explosion entirely gaseous, consisting of carbonic anhydride, carbonic oxide, hydrogen, nitrogen and aqueous vapour, with generally a small quantity of marsh gas.

The water collected, after the explosion vessel was opened, always smelt, occasionally very strongly, of ammonia, and an appreciable amount was determined in the water.

In examining the gaseous products of the explosion of various samples of gunpowder, it was noted that as the pressure under which the explosion took place increased, the quantity of carbonic anhydride also increased, while that of carbonic oxide decreased. The same peculiarity is exhibited by all the explosives with which I have experimented. I show in Table II. the result of a very complete series of a sample of gun-cotton fired under varying pressures, and it will be noted that the volumes of carbonic oxide and carbonic anhydride are, between the highest and lowest pressures, nearly exactly reversed.

TABLE II.

Constituents	Under pressure of explosion, tons per square inch						
	2 tons	8 tons	12 tons	18 tons	20 tons	45 tons	50 tons
vols.							
CO_2 ...	21·44	25·06	26·27	27·21	26·75	28·13	29·27
CO ...	29·66	26·31	25·08	25·24	24·53	23·19	22·31
H	15·92	15·33	16·03	14·56	14·77	14·14	13·56
N	13·63	13·80	13·22	13·13	13·43	12·99	13·07
H_2O ...	19·09	19·09	19·09	19·09	19·09	19·09	19·09
CH_4 ...	·26	·41	·31	·77	1·47	2·46	2·70

There are slight changes as regards the other products, but they do not compare in importance with that to which I have referred.

But before drawing your attention to other points of interest, it is desirable to give you an idea of the advances in ballistics which have been made both by improvements in the manufacture of the old powders and by the introduction of the new.

On Fig. 2 is placed the results as regards velocity of nine explosives, commencing with the R.L.G. powder, which was in use in the latter part of the fifties, and terminating with the cordite of the present day.

The experiments I am now referring to were made in a gun of 100 calibres in length, and were so arranged that in a single round the velocities could be measured at 16-points of the bore. The chronoscope with which these velocities were taken has been already described, and I will now only say that it is capable of registering time to the millionth of a second with a probable error of between two and three millionths. One curious fact connected with the mode of registration I may mention. In the early experiments with the old powders, where the velocities did not exceed 1500 or 1600 feet-seconds, the arrangement for causing the projectile to record the time of its passing any particular point was effected by the shot knocking down a small steel knife or trigger which projected slightly into the bore; but when the much higher velocities, with which I subsequently experimented, were employed, this plan was found to be unsatisfactory, the steel trigger, instead of being immediately knocked down by the shot, frequently preferred instead to cut a groove in the shot, sometimes nearly its whole length, before it acted. Hence another arrangement for cutting the primary wires had to be adopted.

The diagram I am now showing you is, however, both interesting and instructive. The intention, among other points, was to ascertain for various calibres in length in a 6-inch gun the velocities and energies that could be obtained, the maximum pressures, whether mean or wave, not exceeding about 20 tons on the square inch. The horizontal line or axis of abscissæ represents the travel of the shot in feet, the ordinates or perpendiculars from this line to the curve represents the velocity at that point.

The lowest curve on the diagram gives, under the conditions I have mentioned, the velocities attainable with the powder which was used when rifled guns were first introduced into the service, and you will note that with this powder the velocity attained with 100 calibres was only 1705 foot-seconds, while with 40 calibres it was 1533 foot-seconds. Next on the diagram comes pebble powder with a velocity of 2190 foot-seconds; next comes brown prismatic with a velocity of 2529 foot-seconds.

The next powder is one of considerable interest, and one which might have arisen to importance had it not been superseded by explosives of a very different nature. It is called Amide powder, and in it ammonium nitrate is substituted for a large portion (about half) of the potassium nitrate, and there is also an absence of sulphur. You will observe the velocity in the 100 calibre gun is very good, 2566 foot-seconds. The pressure also was low and free from wave action. It is naturally not smokeless, but the smoke is much less dense and disperses much more rapidly than does the smoke of ordinary powder. Its great advantage, however, was that it eroded steel very much less than any other powder with which I experimented, while its great disadvantage was due to the deliquescent properties of ammonium nitrate necessitating the keeping of the cartridges in air-tight cases.

Next on the diagram comes B.N. or Blanche Nouvelle powder, an explosive which, while free from wave action, is remarkable, as you will note if you follow the curve, in developing a much higher velocity than the other powders in the first few feet of motion, and less in the later stages of expansion.

Thus, if you compare this curve with the highest curve on the diagram, that of the four-tenths cordite, you will note that the B.N. curve for the first eight feet of motion is the higher, and that at about eight feet the curves cross, the B.N. giving a final velocity of 2786 foot-seconds, or 500 feet below the cordite curve.

Then follows ballistite, which, with much lower initial pressure, gives a velocity of 2806 foot-seconds, or somewhat higher than that of B.N. Then follow three different sizes of cordite, the highest of which gives a muzzle velocity of 3284 foot-seconds, or a velocity nearly double that of the early R.L.G.

TABLE III.—*6-inch Gun, 100 Calibres long. Velocities and Energies realised with High Explosives. Weight of Projectile, 100 lbs.*

Nature and Weight of Explosive.	Length of Bore, 40 Calibres.		Length of Bore, 50 Calibres.		Length of Bore, 75 Calibres.		Length of Bore, 100 Calibres.	
	Velocity.	Energy.	Velocity.	Energy.	Velocity.	Energy.	Velocity.	Energy.
	f. s.	ft.tons	f. s.	ft tons	f. s.	ft.ton	f. s	ft.ton
Cordite, ·4 in. (27·5 lbs.)	2794	5413	2940	5994	3166	6950	3284	7478
Cordite, 0·35 in. (22 lbs.)	2444	4142	2583	4626	2798	5429	2915	5892
Cordite, 0·3 in. (20 lbs.)	2495	4316	2632	4804	2821	5518	2914	5888
Ballistite, 0·3 in. cubs. (20 lbs.)	2416	4047	2537	4463	2713	5104	2806	5460
French B.N. (25 lbs.)	2422	4068	2530	4438	2700	5055	2786	5382
Amide prism (32 lbs.)	2225	3433	2331	3768	2486	4285	2566	4566
Brown prism (50 lbs.)	2145	3190	2257	3532	2435	4111	2529	4485
Pebble powder (36 lbs.)	1885	2464	1980	2718	2110	3087	2190	3326
R.L.G_2 (23 lbs.)	1533	1630	1592	1757	1668	1929	1705	2016

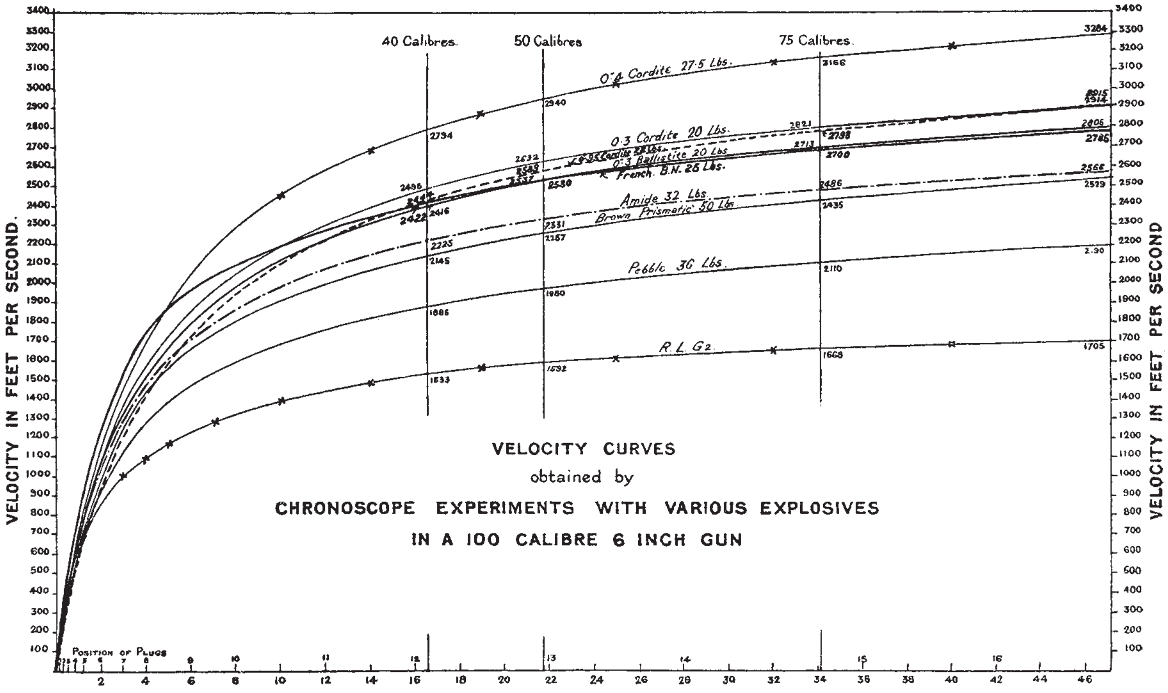

FIG. 2.

In the somewhat formidable-looking Table III. I have placed on the wall are exhibited the velocities and energies realised in a 6-inch gun with the various explosives I have named, and the Table, in addition, shows the velocities and energies in guns of the same calibre but of 40, 50 and 75 calibres in length, as well as in that of 100 calibres.

If you compare the results shown in the highest and lowest lines of this table, that is, the results given by the highest and lowest curves on the diagram, you will see that the velocity of the former is nearly twice as great as that of the latter, while its energy and capacity for penetration is nearly four times as great.

I need hardly remind most of you that in artillery matters it is the energy developed, not the velocity alone, that is of vital importance. I venture to insist upon this point, because so many of those who desire to instruct the authorities, write as if velocity were the only point to be considered. In a given gun with a given charge, if the weight of the shot, within reasonable limits, be made to vary, the ballistic advantage is greatly on the side of the heavier shot, and for three principal reasons.

(1) More energy is obtained from the explosive.

(2) Owing to the lower velocity the resistance of the air is greatly reduced.

(3) The heavier shot has greater capacity for overcoming the reduced resistance.

You will observe that on this velocity diagram, upon which I have kept you so long a time, is shown, not only the travel of the shot in feet, but the position of the plugs which gave the velocities. Further, on the higher and lower curves, the observed velocities are shown where it is possible to do so. Near the origin of motion the points are so close that is is not possible to insert them without confusing the diagram.

At the risk of fatiguing you, I show, in Fig. 3, curves showing the pressure existing in the bore at all points, these pressures being deduced from the curves of velocity.

You will note the point to which I drew your attention, with regard to the powder called B.N. You will remember that in the early stages of motion it gave velocity to the shot much more rapidly than did the other powders. You see the effect in the pressure curves, the maximum being considerably higher than any of the other pressures, while the pressure towards the muzzle is, on the other hand, considerably below the average.

I fear you may think I have kept you unnecessarily long with these somewhat dry details, but I have had reasons for so doing.

In the first place I desire to demonstrate to you the enormous advances which have been made in artillery by the introduction of the new explosives, and which we in a great measure owe to the distinguished chemists and physicists who have occupied themselves with these important questions.

Secondly, I desire to show you that the explosive which has been adopted by this country, and which we chiefly owe to the labours of Sir F. Abel and Prof. Dewar, is in ballistic effect inferior to none of its competitors. I might go further and say that it is decidedly superior.

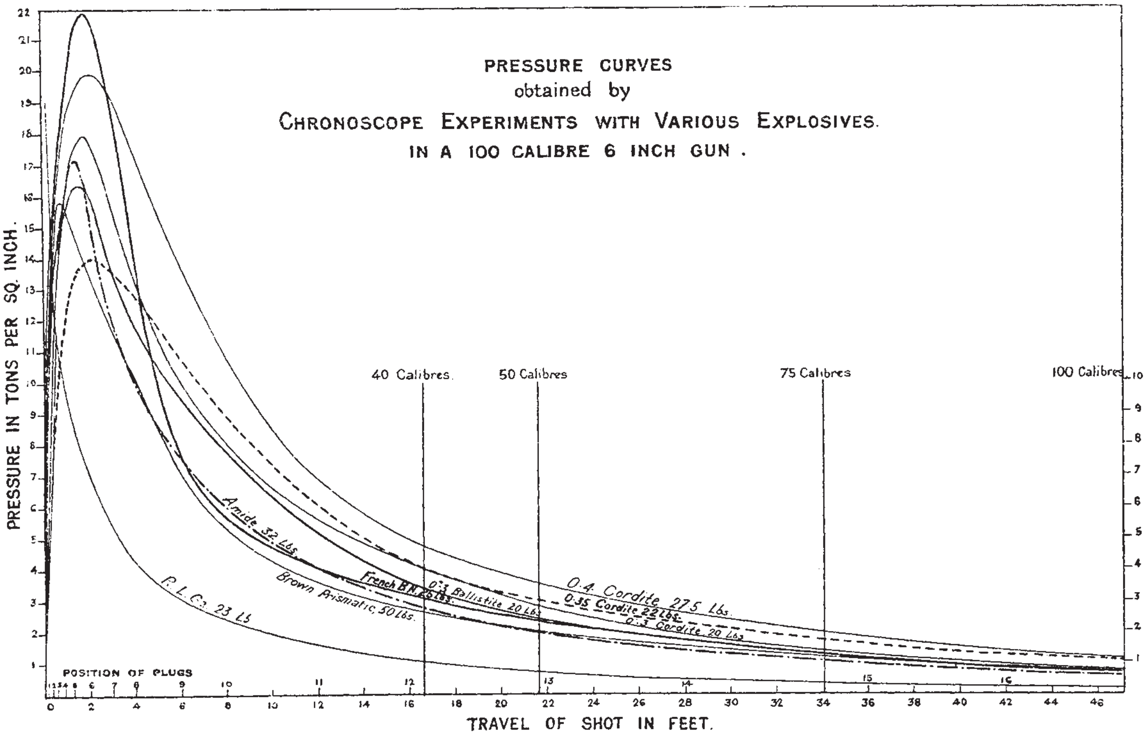

FIG. 3.

Lastly, at a time when the efficiency of all our arms, and especially our artillery, is a question which has been deeply agitating the country, I may do some good by pointing out that the authorities are well aware that any practicable velocity or energy they may desire for their guns is at their disposal.

They have such guns, I mean guns with high velocity and high energy—whether they have enough of them, and whether they are always in the right place, is another matter, for which perhaps the military authorities are not altogether responsible. But velocity and energy is not the only thing that is required under all circumstances in war, and I ask you to believe that if the War Office authorities have, for their field guns, fixed on a velocity very much below what is possible, they have had sound and sufficient reasons for so doing.

My firm and I, individually, have had much to do with the introduction of the larger high-velocity and quick-firing guns into our own and other services; but as an old artillery officer, in no way responsible for our field guns, I may perhaps be allowed to say that, whether as regards materiel or personnel, our field artillery is inferior to none anywhere; and I venture to add that in the present war it appears to have been handled in a way worthy of the reputation of the corps.

I fear the causes of some of our military failures at the commencement of the war must be looked for in other directions, and the present unfortunate war will turn out to be a blessing in disguise, if it should awaken the Empire to the necessity of correcting serious defects in our organisation, possibly the natural result of our constitution; and, in that case, the invaluable lives that have been lost will not have been sacrificed in vain.

(*To be continued.*)

THE USE OF STEEL IN SHIPBUILDING.[1]

MANY changes and developments in the construction of ships for the mercantile marine have taken place during the last forty years. At the commencement of this period wood was still the principal material employed for shipbuilding, and although iron had been introduced for general shipbuilding purposes some twenty years earlier, the record of new tonnage added to the British Register in 1860 shows only about 30 per cent. to have been built of iron.

The general adoption of iron for shipbuilding on the Wear dates from about the year 1863, and by 1880 it had, in that district, entirely taken the place of wood. On the Clyde, Mersey and Tyne, iron shipbuilding was adopted at an even earlier date. So far back as 1855, iron had largely taken the place of wood for shipbuilding on the Clyde.

The difficulty of preventing the fouling of the bottoms of iron ships due to corrosion or marine growths, and the consequent loss of speed, led to various attempts being made to sheath the bottoms of iron ships and cover the wood sheathing with copper, yellow metal, or zinc sheets. The result was the introduction of the system of construction known as "Composite," in which the framing was of iron, with wood planking wrought on the iron frames, and sheathed with copper or yellow metal.

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[1] Abstract of a paper read before the Institution of Naval Architects by Mr. B. Martell.